Segment 1426 of the Colorado River
Chloride, Sulfate, Total Dissolved Solids
Total Maximum Daily Load Development

Ballinger, Texas

Meeting #2
April 12, 2004

THE Louis Berger Group, INC.

Recap from Meeting 1

- Explained the TMDLs: What is? Why? Which segment? How?
- Presented and reviewed the steps and the data needed in the development of the TMDL for the listed segment 1426 of the Colorado River.

What is a TMDL?

- A TMDL (Total Maximum Daily Load) establishes the maximum amount of an impairing substance or stressor that a waterbody can assimilate and still meet Water Quality Standards and allocates that load among pollution contributors.

- TMDLs are a tool for implementing State water quality standards. They are based on the relationship between pollution sources and in-stream water quality conditions.

- A TMDL addresses a single pollutant or stressor for each waterbody.

Which Waterbodies Require TMDLs?

Waterbodies require TMDLs when the pollution control requirements are not stringent enough to meet applicable Water Quality Standards.

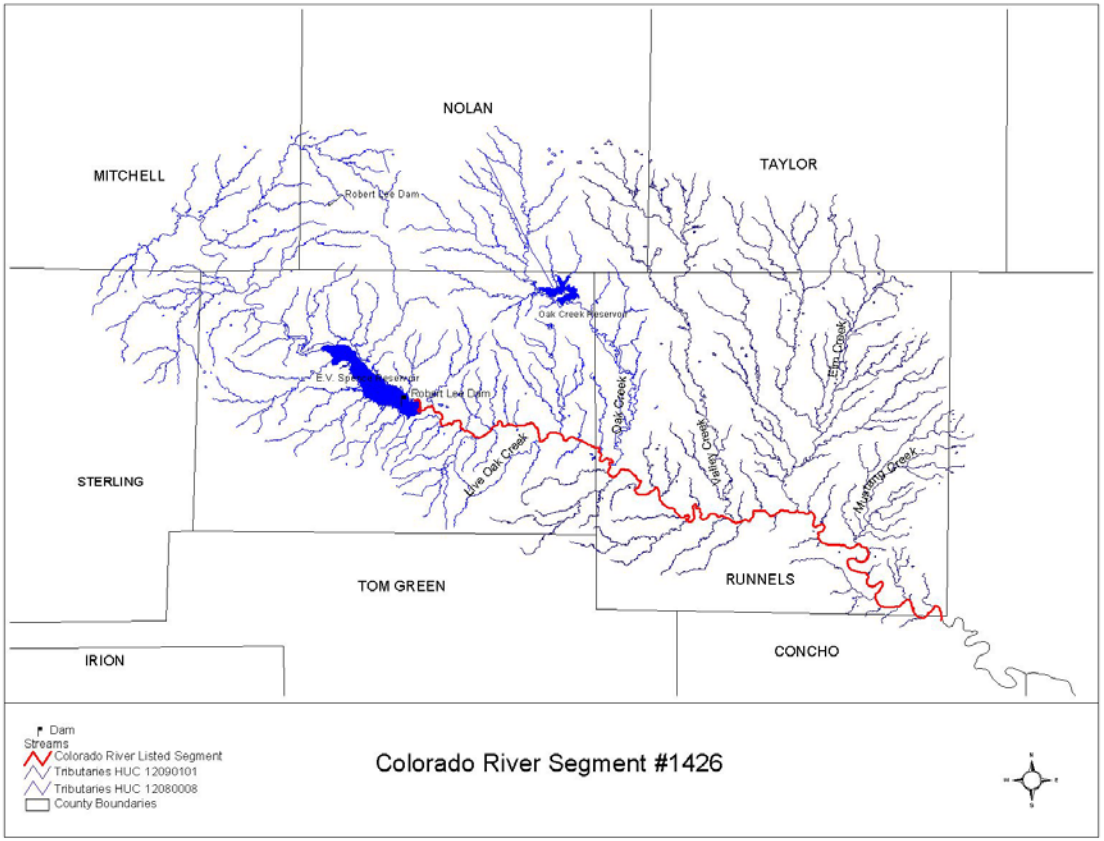
TX Water Quality Standards

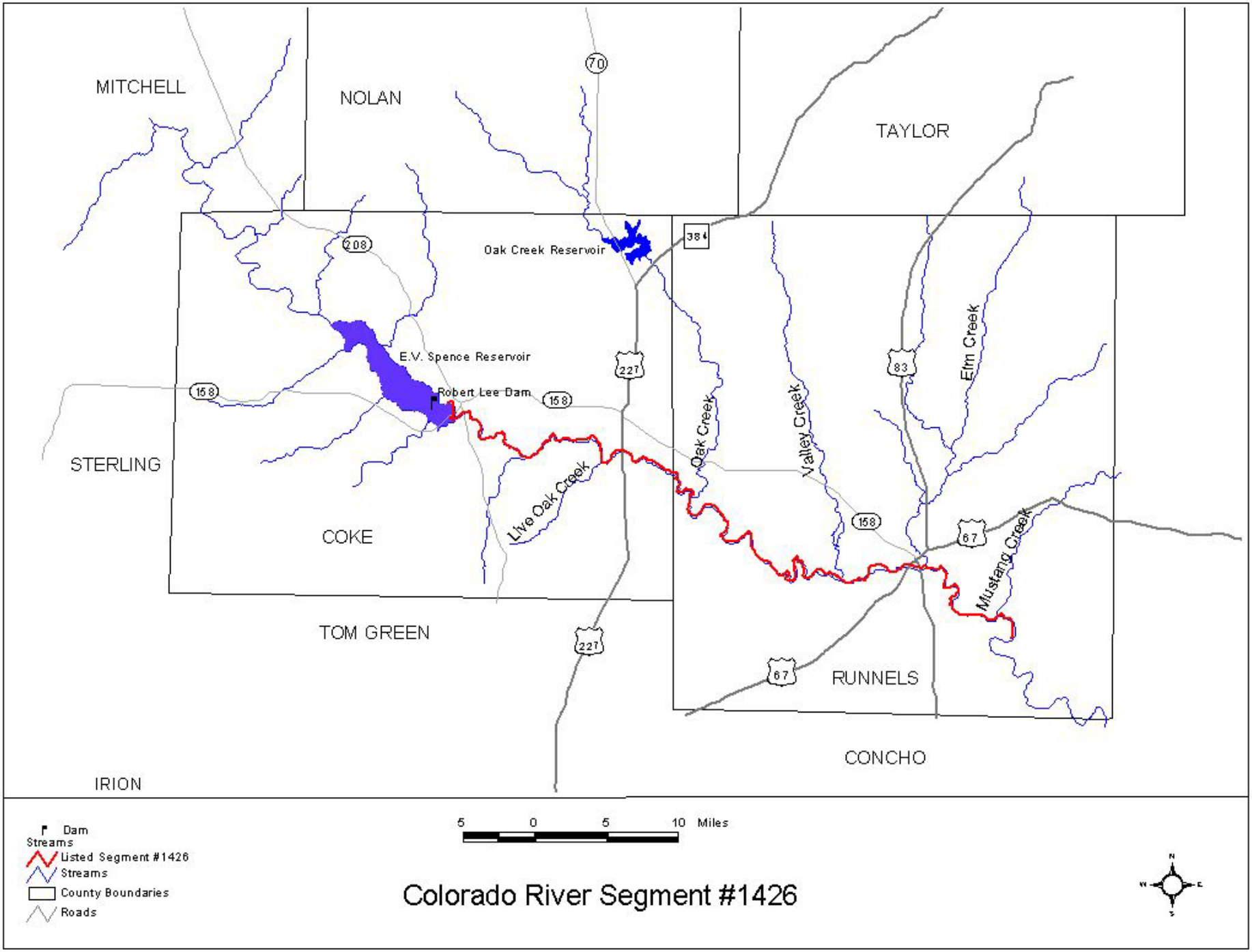
- Chloride, Sulfate, Total Dissolved Solids Impairment
- Appendix A: Water Uses and Numeric Criteria
  - Chloride = 610 mg/L
  - Sulfate = 980 mg/L
  - Total Dissolved Solids = 2,000 mg/L

Colorado River Listed Segment

Based on the 2000 303(d) List

- Upstream Limit:
  - Robert Lee Dam
- Downstream Limit:
  - A point 2.3 miles below Mustang Creek Confluence
- Segment Length:
  - 66 miles




MITCHELL
NOLAN
TAYLOR
70
208
384
Oak Creek Reservoir
E.V. Spence Reservoir
Robert Lee Dam
158
227
83
Elm Creek
Oak Creek
Valley Creek
Live Oak Creek
Mustang Creek
67
STERLING
COKE
TOM GREEN
RUNNELS
CONCHO
IRION
Dam
Streams
Listed Segment #1426
Streams
County Boundaries
Roads
5 0 5 10 Miles
Colorado River Segment #1426

Watershed Characterization

Data Inventory

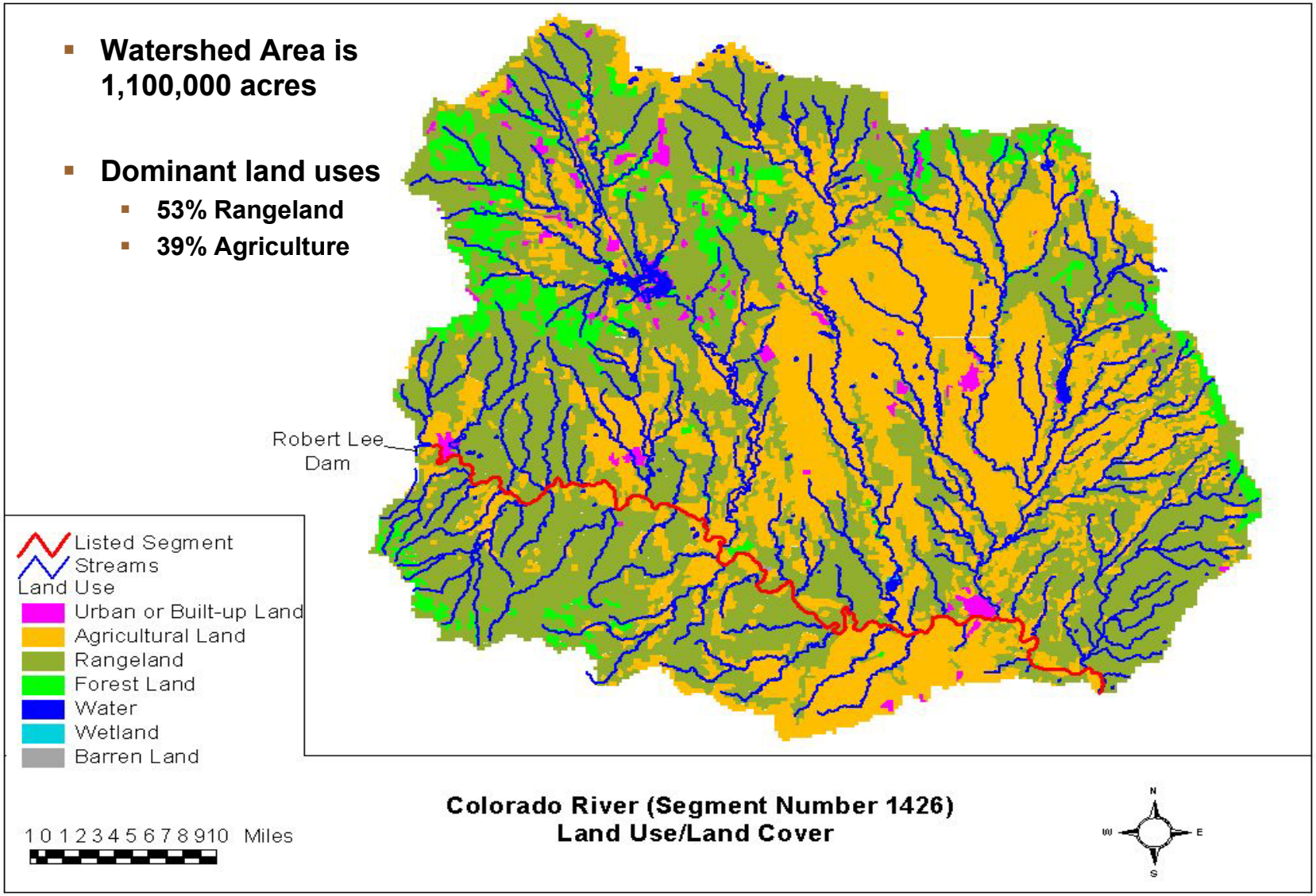
Data Category	Description	Potential Source(s)
Watershed physiographic data	Watershed boundary	USGS, TCEQ
	Land use/land cover	BASINS, MRLC, NLCD, TCEQ
	Soil data (SSURGO, STATSGO)	USDA, NRCS
	Topographic data (USGS-30 meter DEM, USGS Quads)	USGS, TCEQ
Hydrographic data	1. Stream network and reaches (RF3)	BASINS, TCEQ, Field determination
	2. Stream channel morphology	
Weather data	Hourly meteorological conditions	NOAA NCDC, Earth Info, local airports, weather stations, and colleges and universities
Watershed activities/ uses data and information related to pollutant Production	Compile information, data, reports, and maps that can be used to support CL, TDS and Sulfate source identification and loading. Address the following issues:	TCEQ,River Authorities, TSSWCB, RRC, and other State, County and Local agencies
	▪ Leaking oil wells	
	▪ Brine Pits	
	▪ Brine injection	
	▪ Phreatophytic Brush	
	▪ Salt deposits (geological source)	
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMR)	US EPA Permit Compliance System (PCS), TCEQ
Environmental monitoring data	Station locations and ambient instream monitoring data	TCEQ, Monitoring Plan, River Authorities
Stream flow data	Gaging station location and continuous flow data	USGS, TCEQ, River Authorities

Segment 1426 Land Use Data

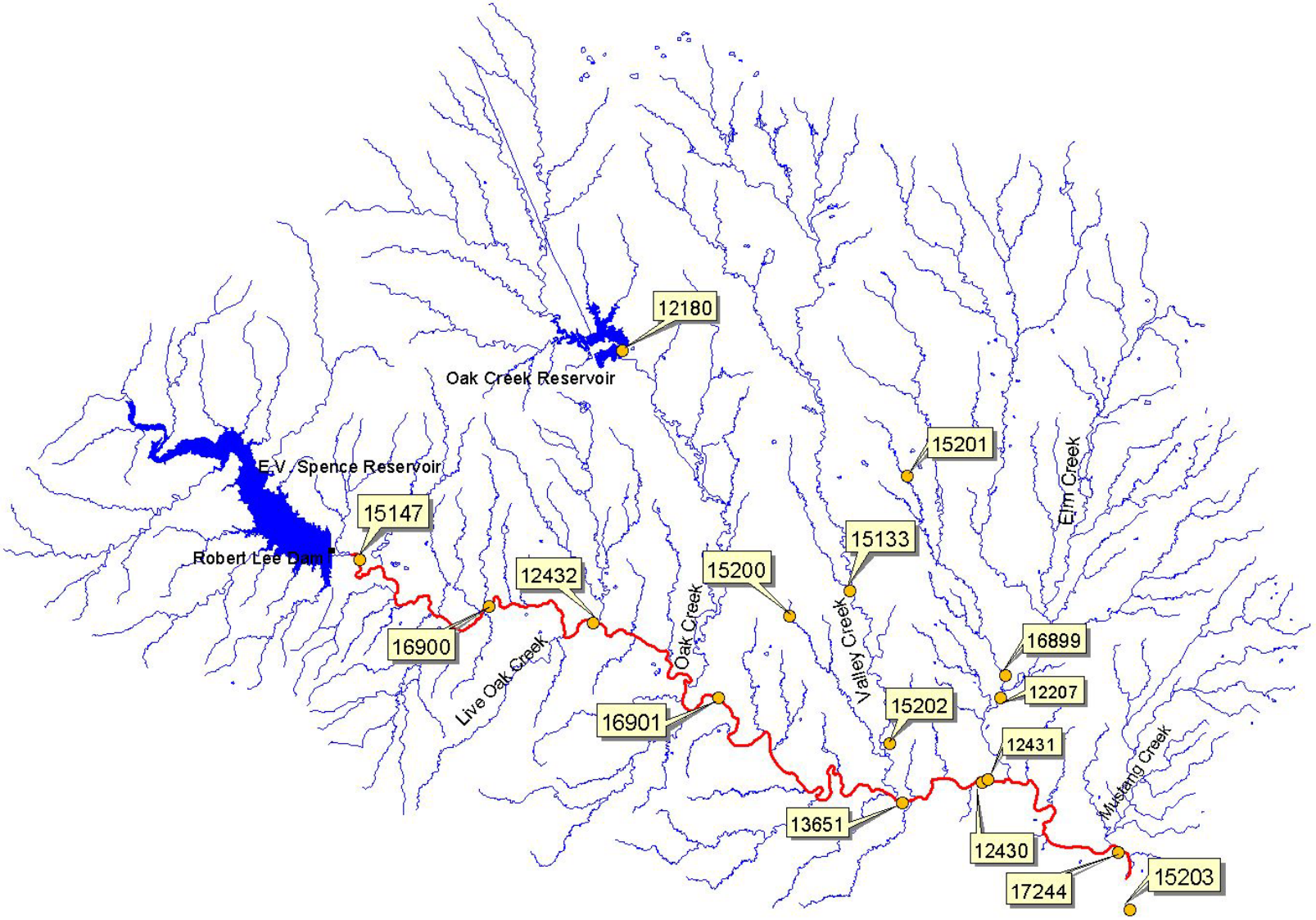
Land Use		Acres	Percent	Total Percent
Urban	COMMERCIAL AND SERVICES	1133	0.1	
	INDUSTRIAL	7727	0.7	
	MXD URBAN OR BUILT-UP	120	0.0	1.4
	TRANS, COMM, UTIL	889	0.1	
	OTHER URBAN OR BUILT-UP	566	0.1	
	RESIDENTIAL	4679	0.4	
Agriculture	CROPLAND AND PASTURE	434038	38.8	
	ORCH,GROV,VNYRD,NURS,ORN	124	0.0	38.8
	OTHER AGRICULTURAL LAND	49	0.0	
	CONFINED FEEDING OPS	41	0.0	
Rangeland	HERBACEOUS RANGELAND	28025	2.5	53.6
	MIXED RANGELAND	267697	23.9	
	SHRUB & BRUSH RANGELAND	304033	27.2	
Forest	DECIDUOUS FOREST LAND	2867	0.3	5.9
	EVERGREEN FOREST LAND	347	0.0	
	MIXED FOREST LAND	63075	5.6	
Water	RESERVOIRS	3001	0.3	0.3
Wetland	NONFORESTED WETLAND	353	0.0	0.0
Barren	STRIP MINES	223	0.0	0.0
	TRANSITIONAL AREAS	99	0.0	
	Total	1119100	100	100

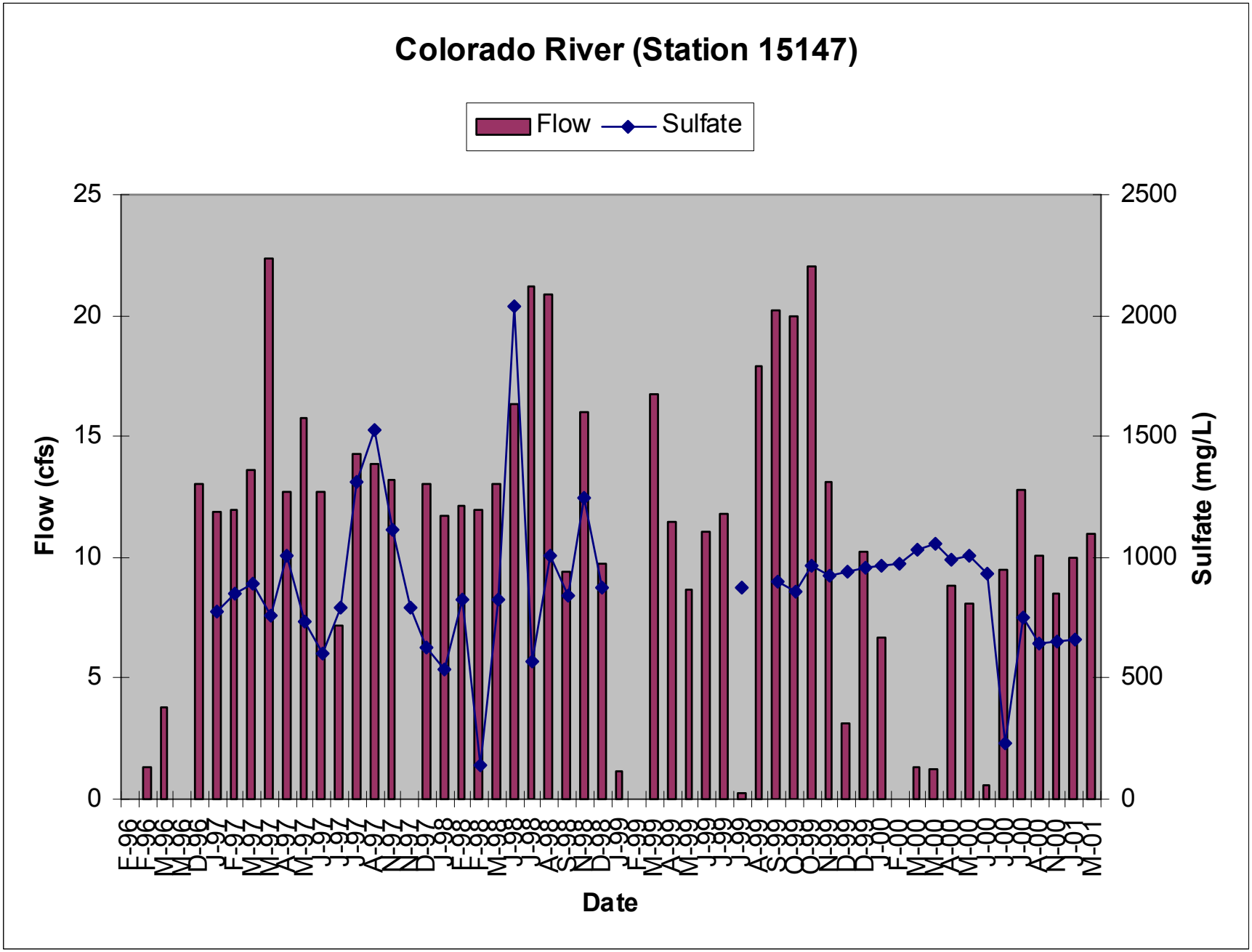
Colorado River-Segment 1426

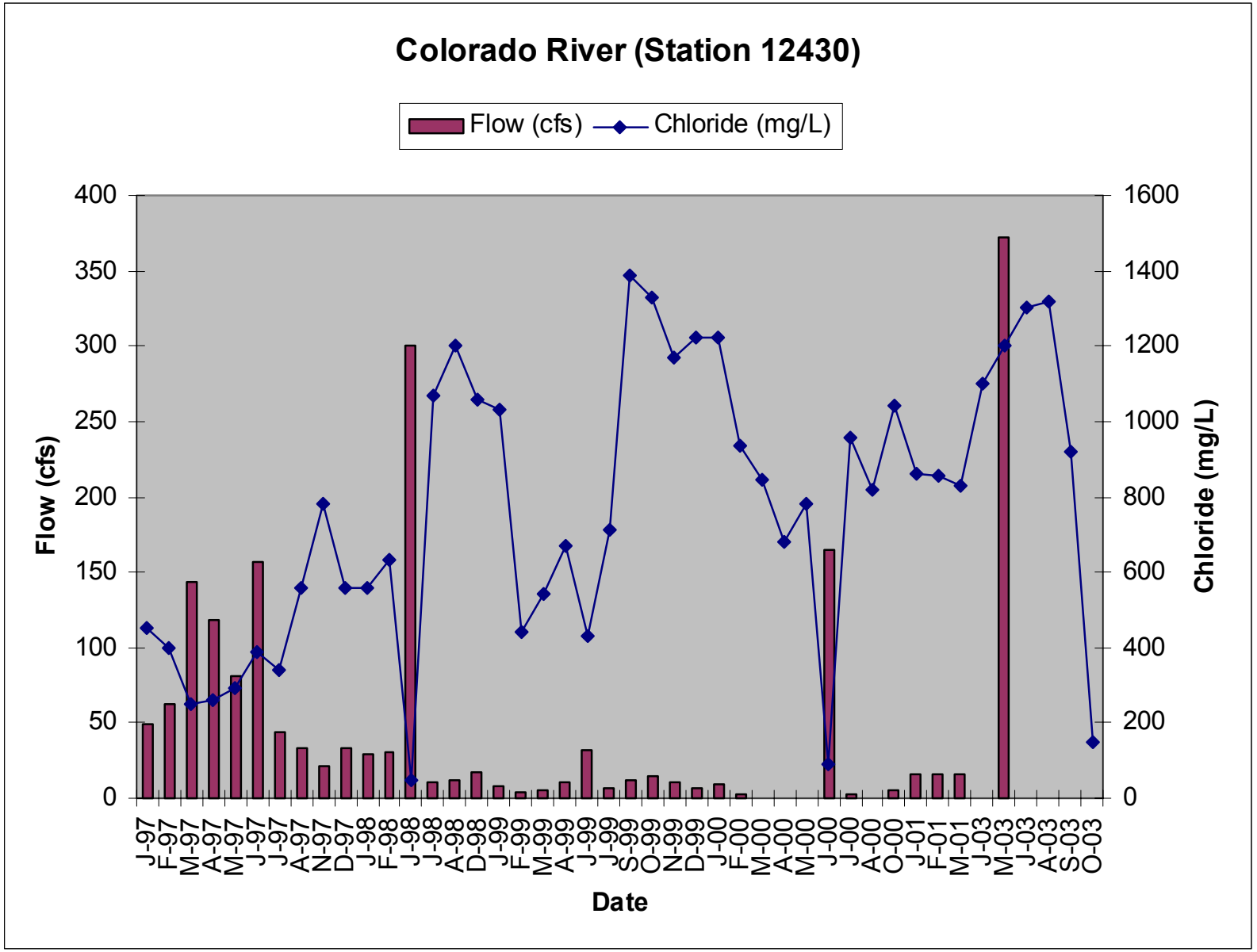
- **Watershed Area is 1,100,000 acres**
- **Dominant land uses**
  - **53% Rangeland**
  - **39% Agriculture**



Environmental Monitoring


12180
Oak Creek Reservoir
E.V. Spence Reservoir
15147
Robert Lee Dam
12432
16900
Live Oak Creek
Oak Creek
15200
16901
15201
Elm Creek
15133
Valley Creek
16899
12207
15202
12431
Mustang Creek
13651
12430
17244
15203
4 0 4 8 Miles
Dam
Monitonring Stations
Listed Segment #1426
Streams
Colorado River Segment #1426
Water Quality Monitoring Stations
N
W
E
S


Colorado River (Station 15147)
Flow
Sulfate
Flow (cfs)
Sulfate (mg/L)
Date
0
5
10
15
20
25
0
500
1000
1500
2000
2500


Colorado River (Station 12430)
Flow (cfs)
Chloride (mg/L)
400
350
300
250
200
150
100
50
0
1600
1400
1200
1000
800
600
400
200
0
Flow (cfs)
Chloride (mg/L)
J-97
F-97
M-97
A-97
M-97
J-97
J-97
A-97
N-97
D-97
J-98
F-98
J-98
J-98
A-98
D-98
J-99
F-99
M-99
A-99
J-99
J-99
S-99
O-99
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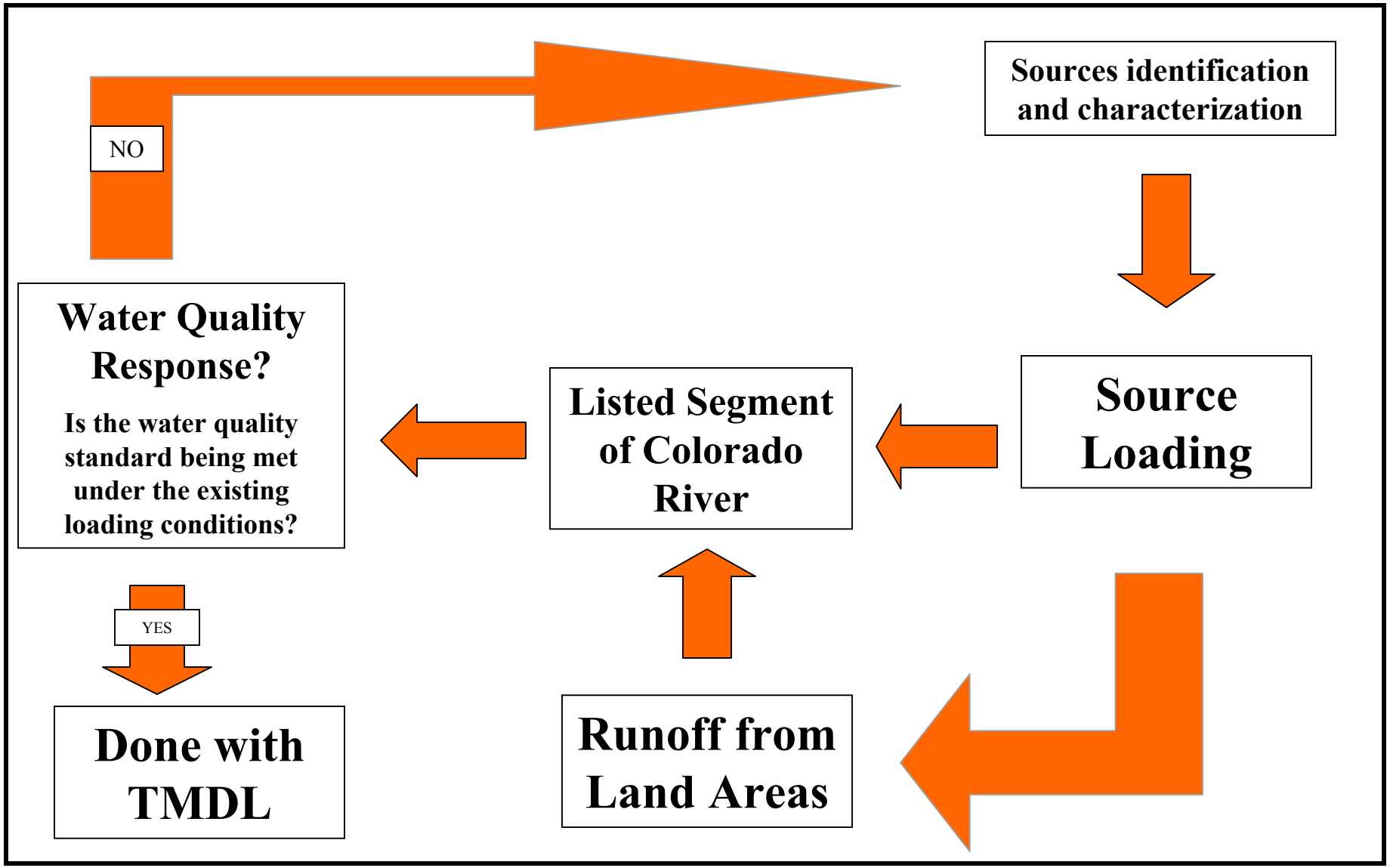
D-99
J-00
F-00
M-00
A-00
M-00
J-00
J-00
A-00
O-00
J-01
F-01
M-01
J-03
M-03
J-03
A-03
S-03
O-03
Date

Environmental Data

- Since the water quality standards are regularly exceeded under both wet and dry weather flow conditions and the sources of chloride and sulfate include sources that contribute to wet weather flows, a detailed model is required to determine the pollutant loads from different types of nonpoint sources and their transport mechanisms.

TMDL Process

TMDL Process



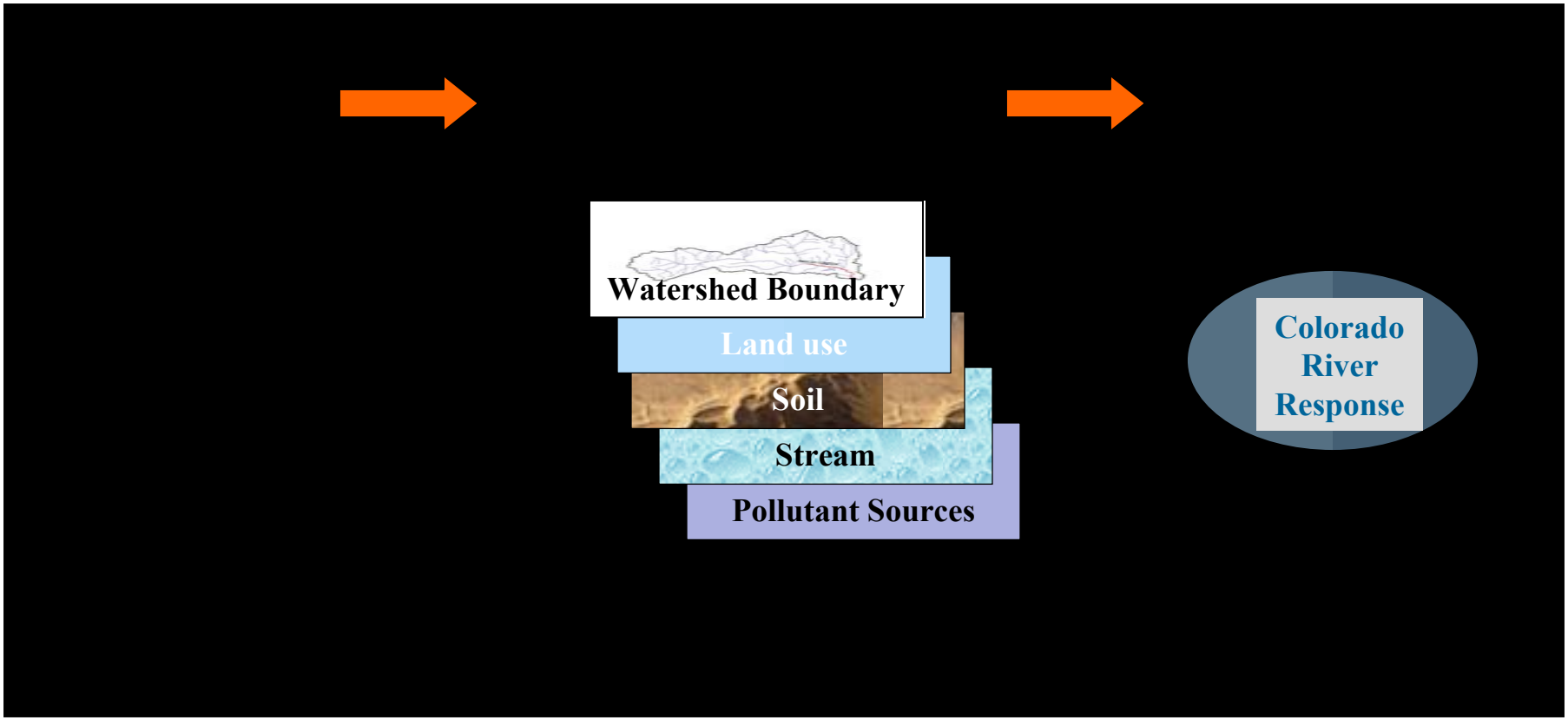
Water Quality Model

Hydrologic Simulation Program Fortran (HSPF)

- Hydrologic Model
- Watershed Model
- State of the art Modeling System
- EPA approved approach

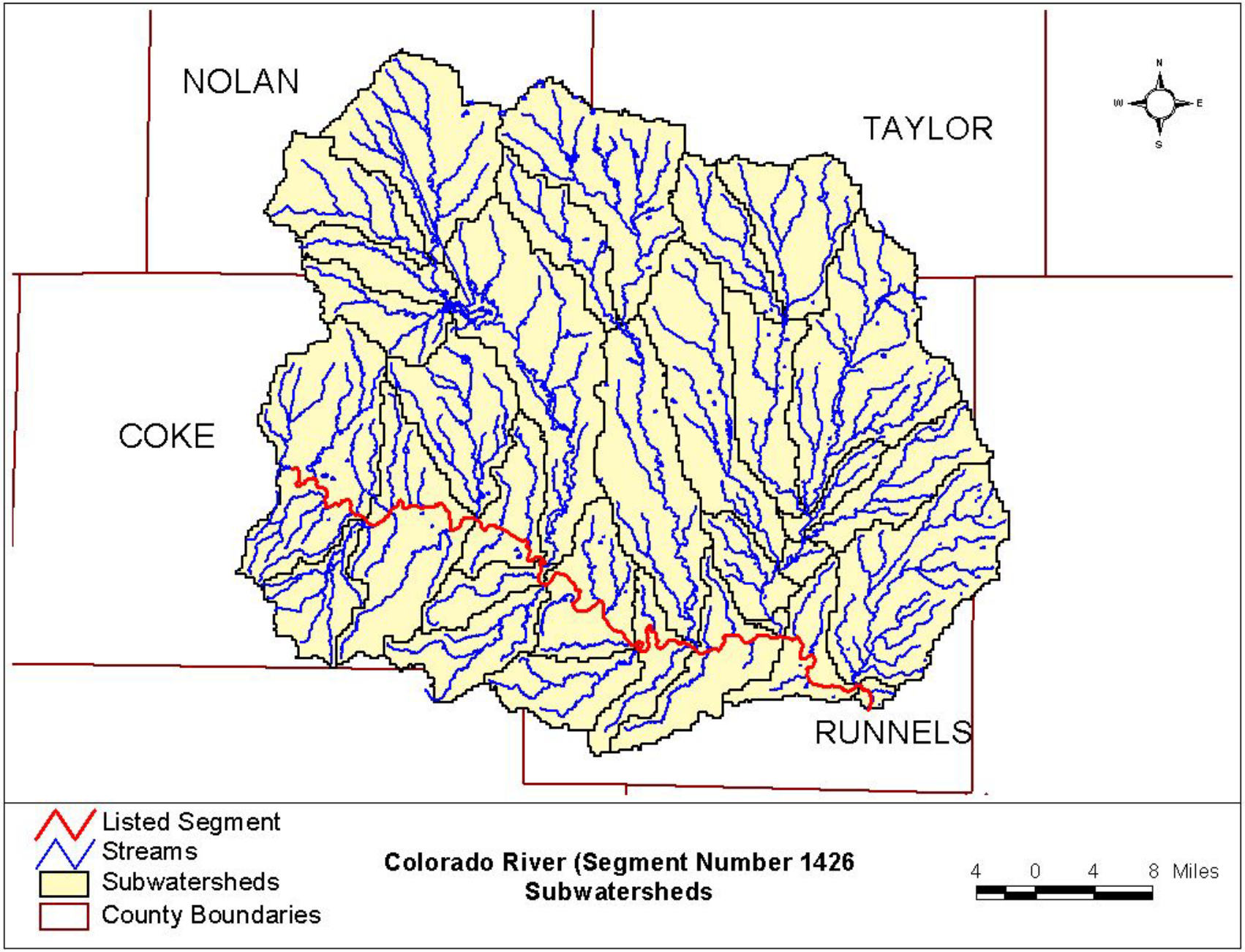
HSPF Model

Linking Sources to Water Quality



HSPF Model

- Model set up
- Model calibration
- Calibration results

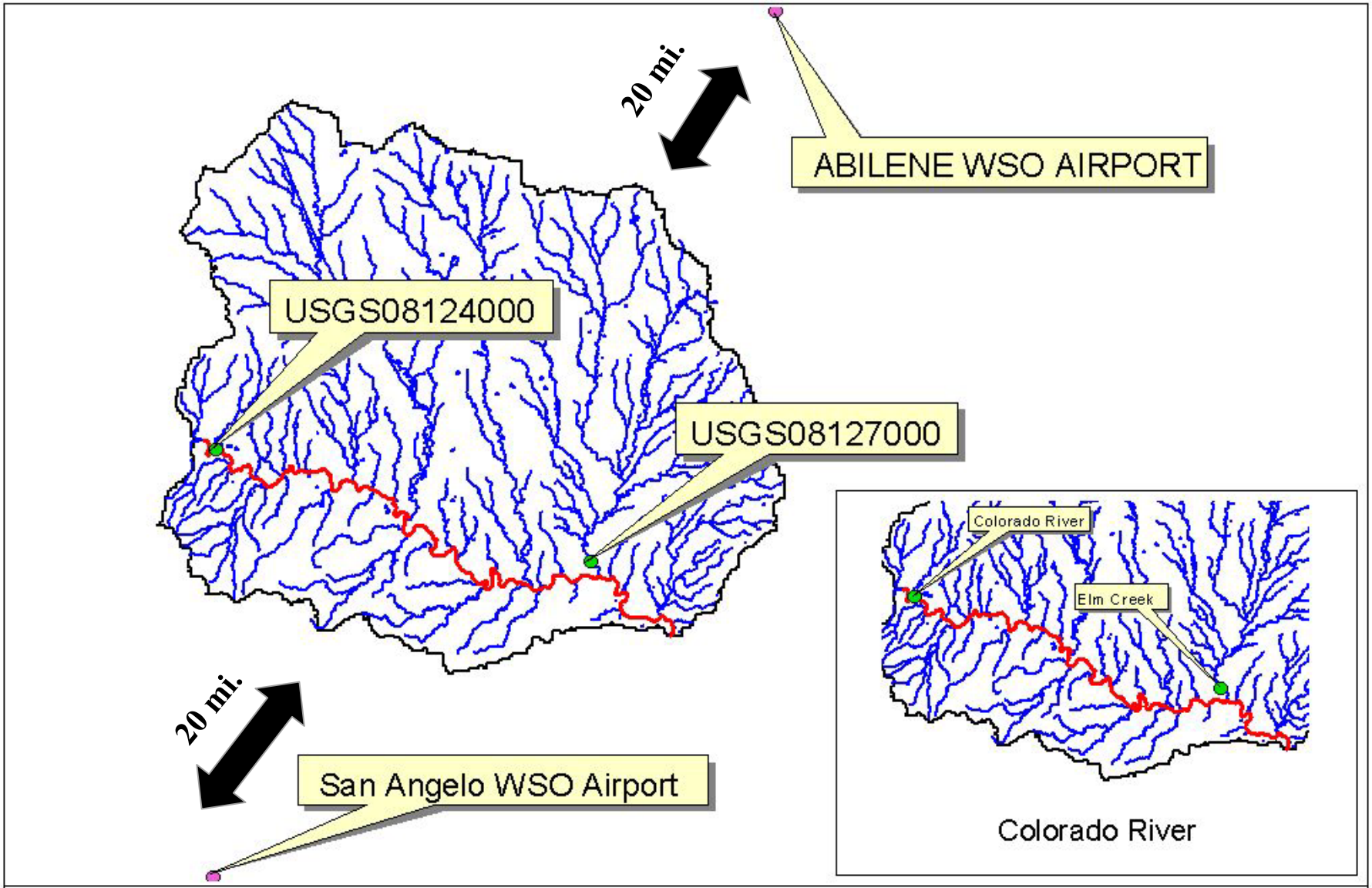

NOLAN
TAYLOR
COKE
RUNNELS
N
W
E
S
Listed Segment
Streams
Subwatersheds
County Boundaries
Colorado River (Segment Number 1426
Subwatersheds
4 0 4 8 Miles

Stream Flow

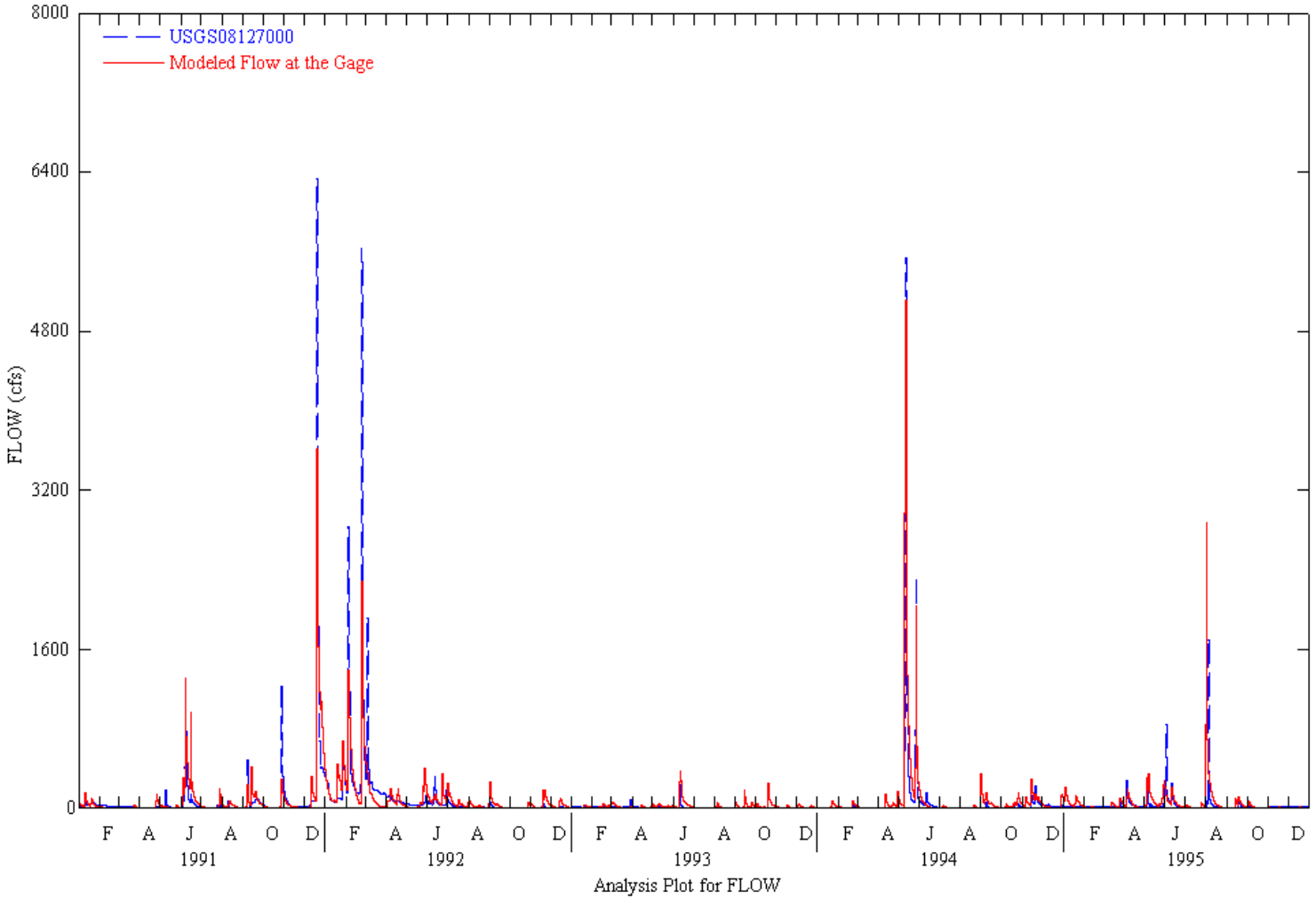
- Current stream flow data exists at two stations in the watershed
  - Station 08124000 on the Colorado River
  - Station 08127000 on Elm Creek

Weather Data

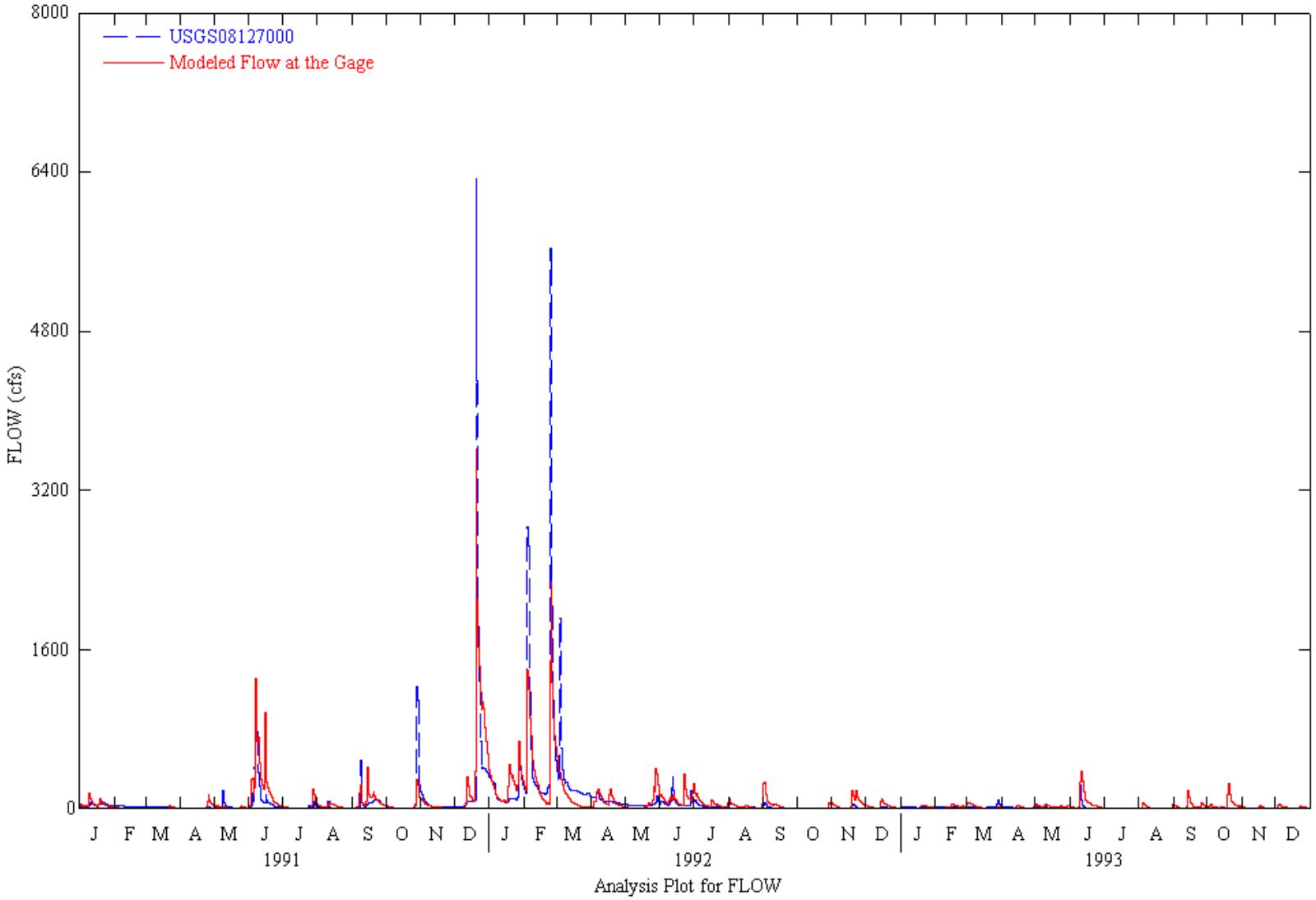
- Current weather data from two weather stations will be used
  - Abilene WSO Airport, approx. 20 miles NE of watershed boundary
  - San Angelo WSO Airport, approx. 20 miles SW of watershed boundary


20 mi.
ABILENE WSO AIRPORT
USGS08124000
USGS08127000
20 mi.
San Angelo WSO Airport
Colorado River
Elm Creek
Colorado River
Weather Stations
Usgs Gauges
Listed Segment
Streams
Watershed Boundary
Colorado River(Segment Number 1426)
USGS Flow Monitoring Stations
and Weather Stations
N
W
E
S
3 0 3 6 Miles

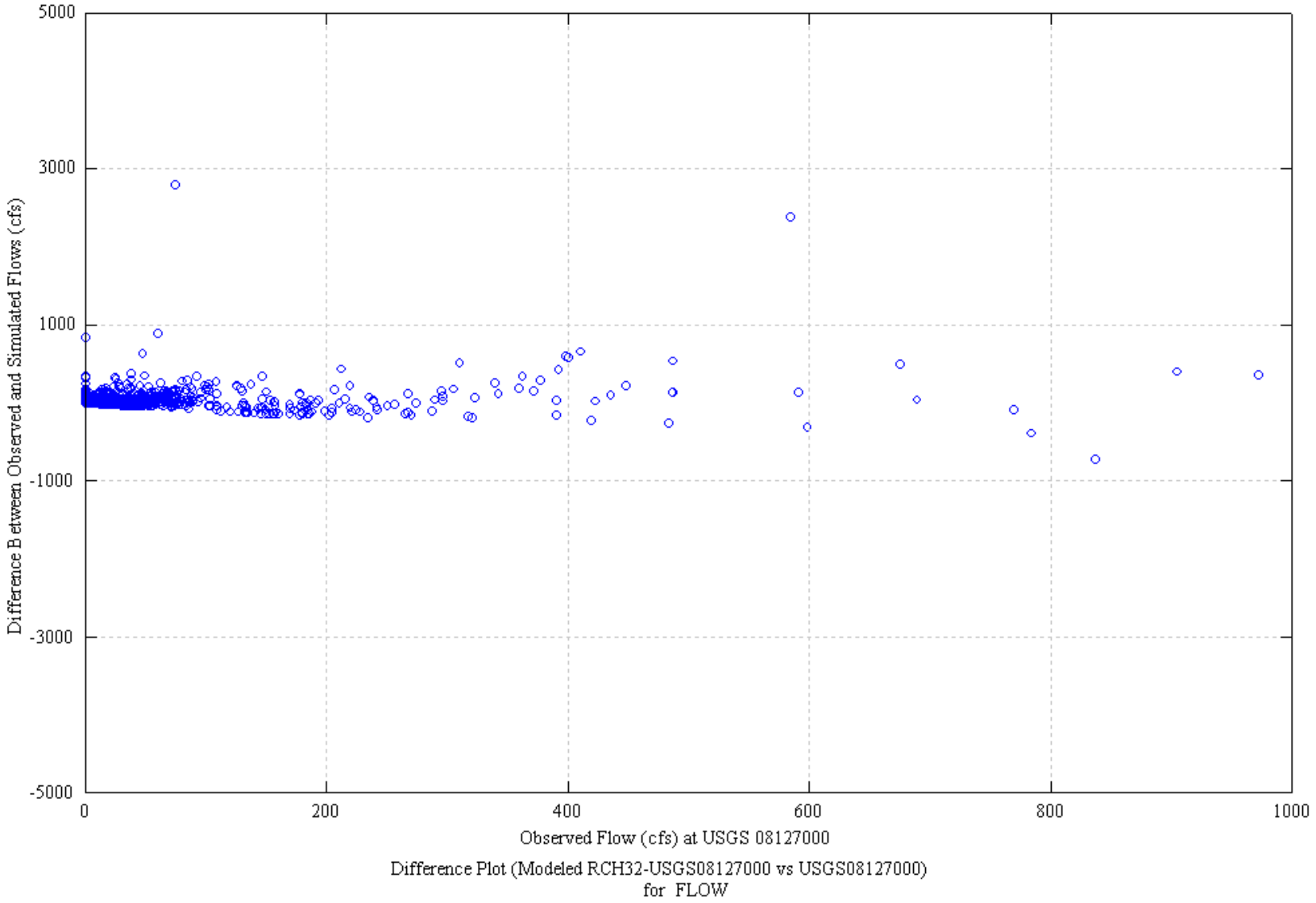
HSPF Model Calibration



HSPF Calibration



HSPF Calibration Results



Next Step

- Issues:
  - Need more site specific hourly rainfall data

Sources

Salinity Sources

Sources of salinity may be originating from:

- Natural Sources:
  - Geologic Formations
  - Biological Sources – Phreatophytic Brush
- Human Sources
  - Permitted Facilities
  - Brine Pits and Injections
  - Leaking Wells

Potential Sources Characterization

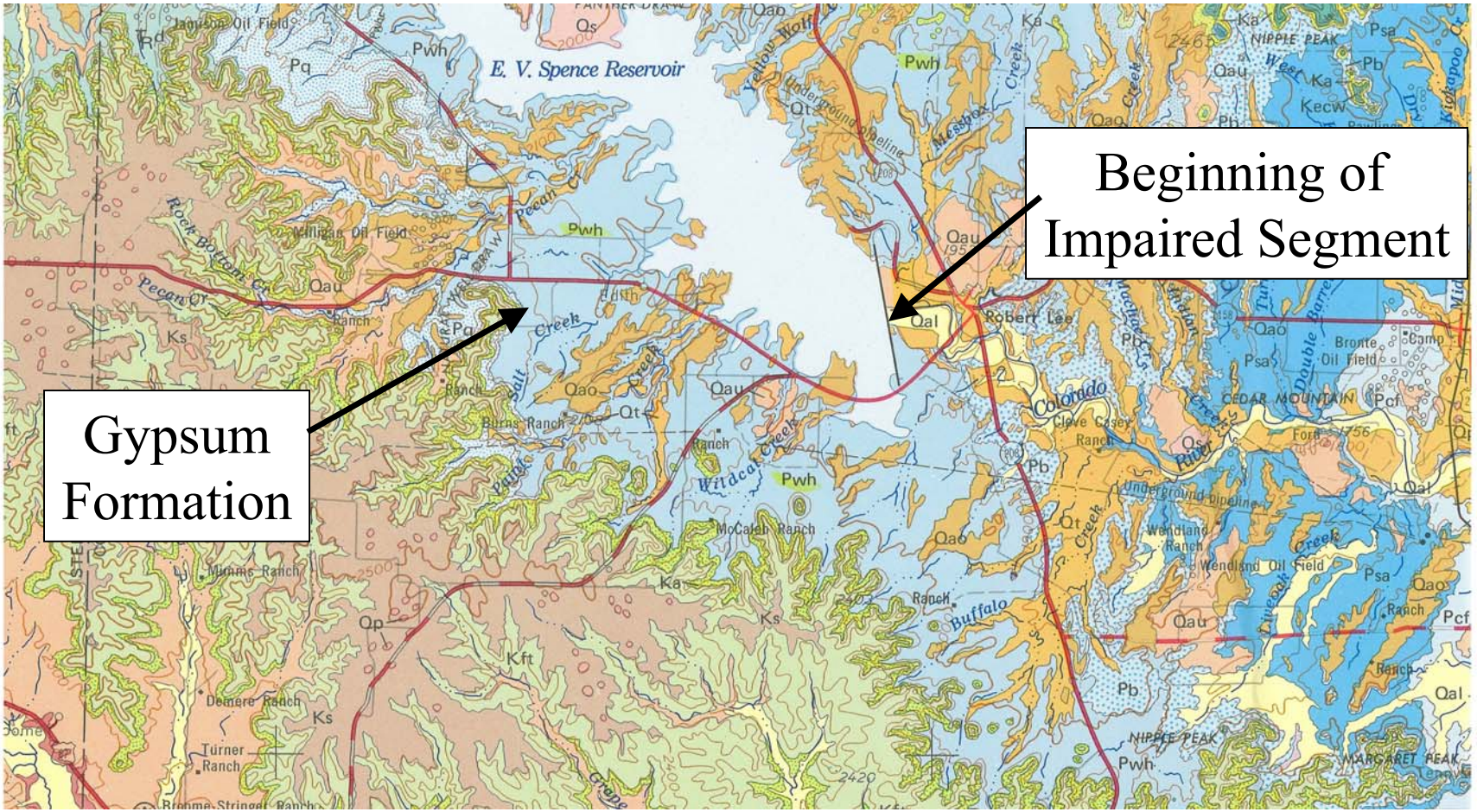
Source	Receiving Water				Response
	Surface Water		Groundwater		
	Direct	Indirect	Shallow	Deep	
Permitted Point source	X				F
Brine Pit		X			F
			X		M
Leaking oil well			X		M
Brine Injection			X		M
				X	S
Phreatophytic Brush		X	X		M
Salt Deposits		X	X		M

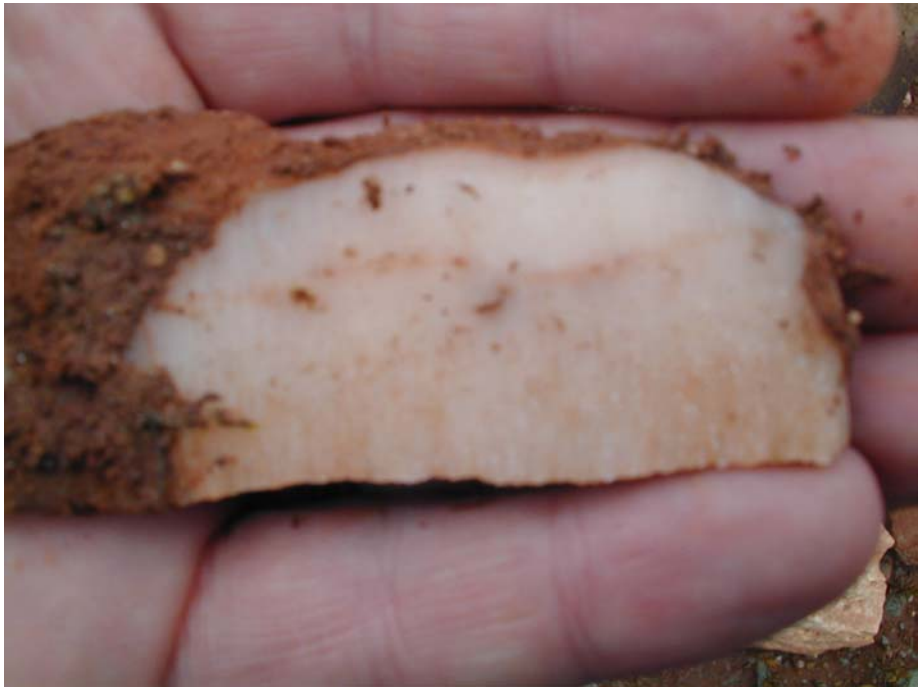
Geologic Sources

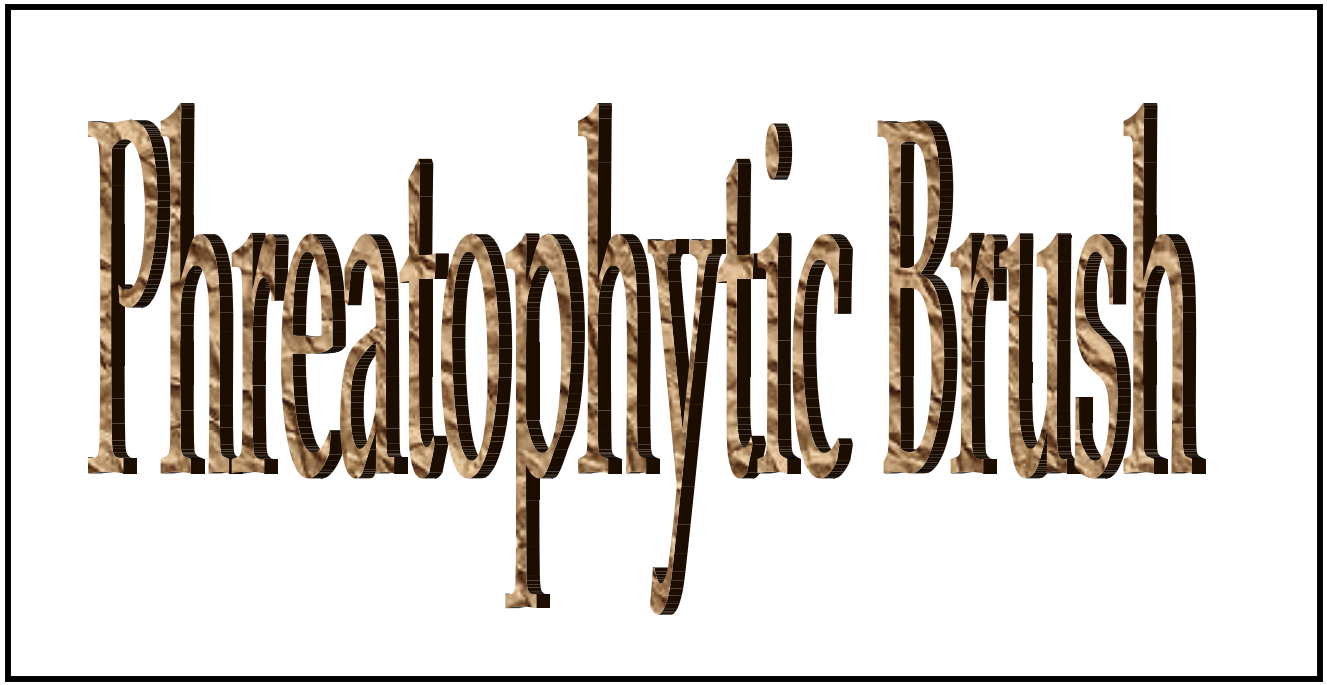
Geologic Sources

- Increased salinity may occur from the dissolution of naturally occurring geologic formations, such as gypsum
- Geologic formations containing gypsum are present in the upper portion of Colorado River segment 1426

Geologic Formations






Phreatophytic Brush

Phreatophytic Brush

- Salt Cedar (Tamarisk sp.)
- One of the most invasive, community-altering shrub-trees in the Southwestern United States
- Dominant plant in many riparian areas of the Colorado River.

Salt Cedar

- Salt Production:
  - Secretes salt from leaves when transpiring
  - Water evaporates, salt falls to the soil
  - Salt concentrations secreted from leaf glands estimated at 41,000 ppm (Wiesenborn 1996)

- Other Problems:
  - Tolerant of higher soil salinity than other plants
  - Uses more water than native plants

Human Sources

Oil-Related Sources

Oil-related activities that may potentially contribute to increased salinity include:

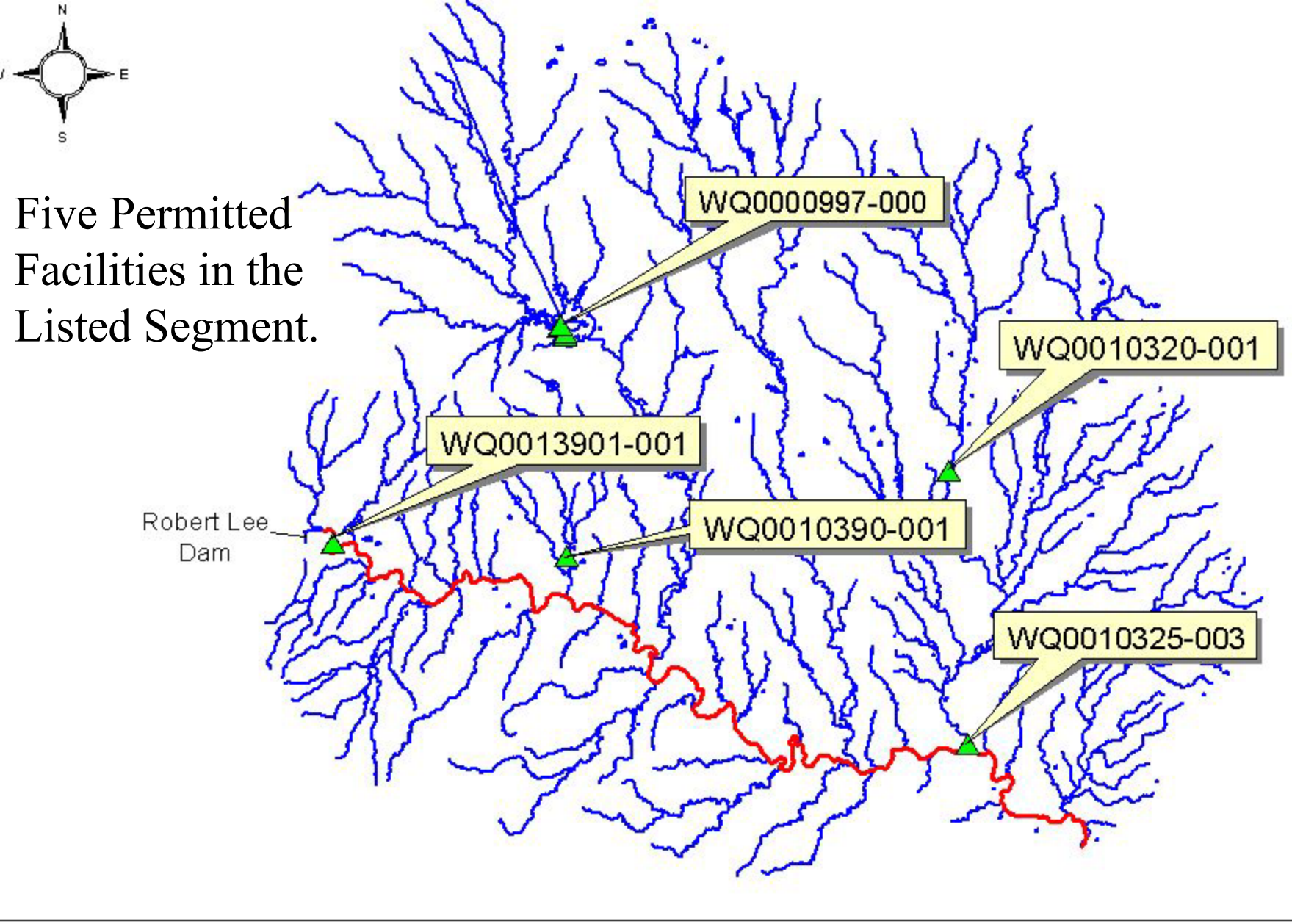
- Brine Injection
- Brine Pits
- Leaking Oil Wells

Permitted Facilities

Five permitted facilities are located in the listed segment of the Colorado River watershed

Permit #	Name of Facility	Design Flow (MGD)	Pemit Date	Latitude	Longitude
WQ0000997-000	Oak Creek SES	60	4/17/01 - 09/01/04	320234	1001719
WQ0010320-001	City of Winters	0.53	12/22/00 -09/01/04	315631	995704
WQ0010325-003	Plant No. 2 City of Ballinger	0.375	09/27/99 - 09/01/04	314414	995606
WQ0010390-001	City of Bronte	0.15	05/16/00 -09/01/04	315238	1001714
WQ0013901-001	City of Robert Lee	0.121	06/23/00 - 09/01/04	315311	1002928

Five Permitted Facilities in the Listed Segment.



Source Loading Estimates

Sources Loading Estimates

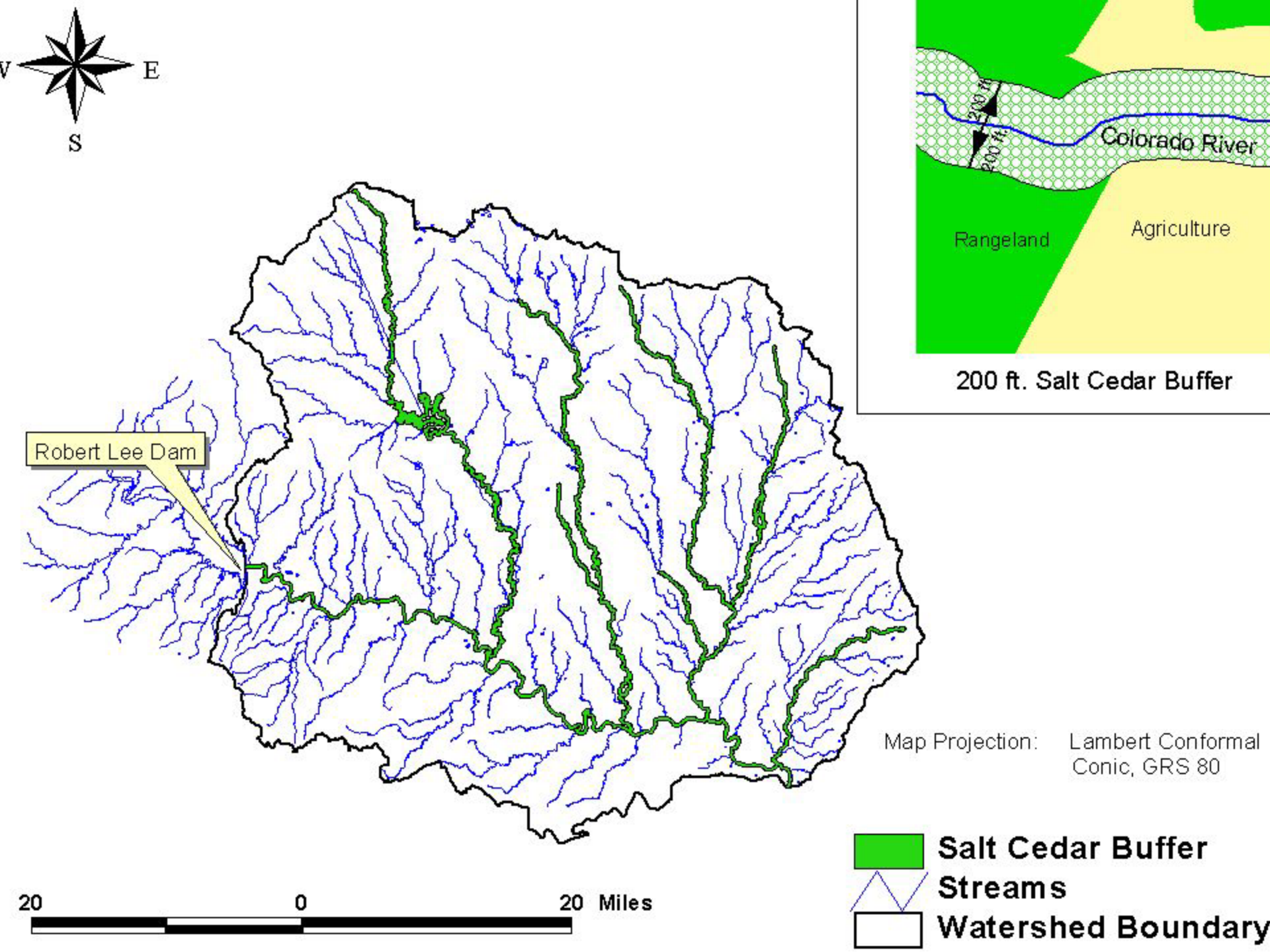
- Determine the daily pollutant production by source
- Estimate the size/number of each source
- Determine whether the source is
  - Direct Source
  - Indirect Source
- Calculate the load to each land use based on a monthly schedule and for each source
- The sum of all the individual sources is the total load

Phreatophytic Brush

- Salinity loads from Salt Cedar will be calculated based on literature values and GIS analyses
  - Salt Cedar density values from literature
  - Salt Cedar buffer around mainstem and major tributaries
  - Salt production calculated based on salt excretion and transpiration rates

Phreatophytic Brush Estimation

- Average Salt Cedar density along stream banks of Colorado River estimated at 23,376 plants per acre (Hays 2003)
- 200 foot stream buffer: 75,750 acres
- 78 gallons per tree per day (Land and Water, Nov/Dec 2003)
- 41,000 mg/L salt in respired water


W
E
S
Robert Lee Dam
200 ft.
200 ft.
Colorado River
Rangeland
Agriculture
200 ft. Salt Cedar Buffer
Map Projection: Lambert Conformal Conic, GRS 80
20
0
20 Miles
Salt Cedar Buffer
Streams
Watershed Boundary

Phreatophytic Brush Load Estimation

- Using the Salt Cedar density along stream banks of Colorado River, a 200 foot stream buffer, water uptake of 78 gallons per tree per day, and 41,000 mg/L salt in respired water yields:
  - Approx 130 billion gallons PER DAY of water use by plants
  - Subsequently an unrealistic Salt Load??

Geologic Sources

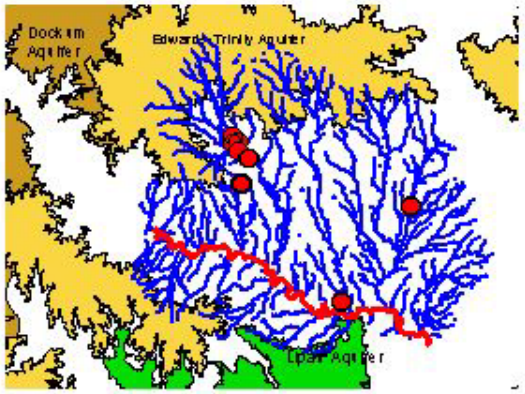
Salinity loads derived from natural geologic formations will be determined from the following data:

- Groundwater wells water quality data
- Surface water quality data
- Estimates of natural salinity sources in the watershed

Colorado River Well Data

N
W E
S

Map Projection: Lambert Conformal Conic, GRS 80



Colorado River

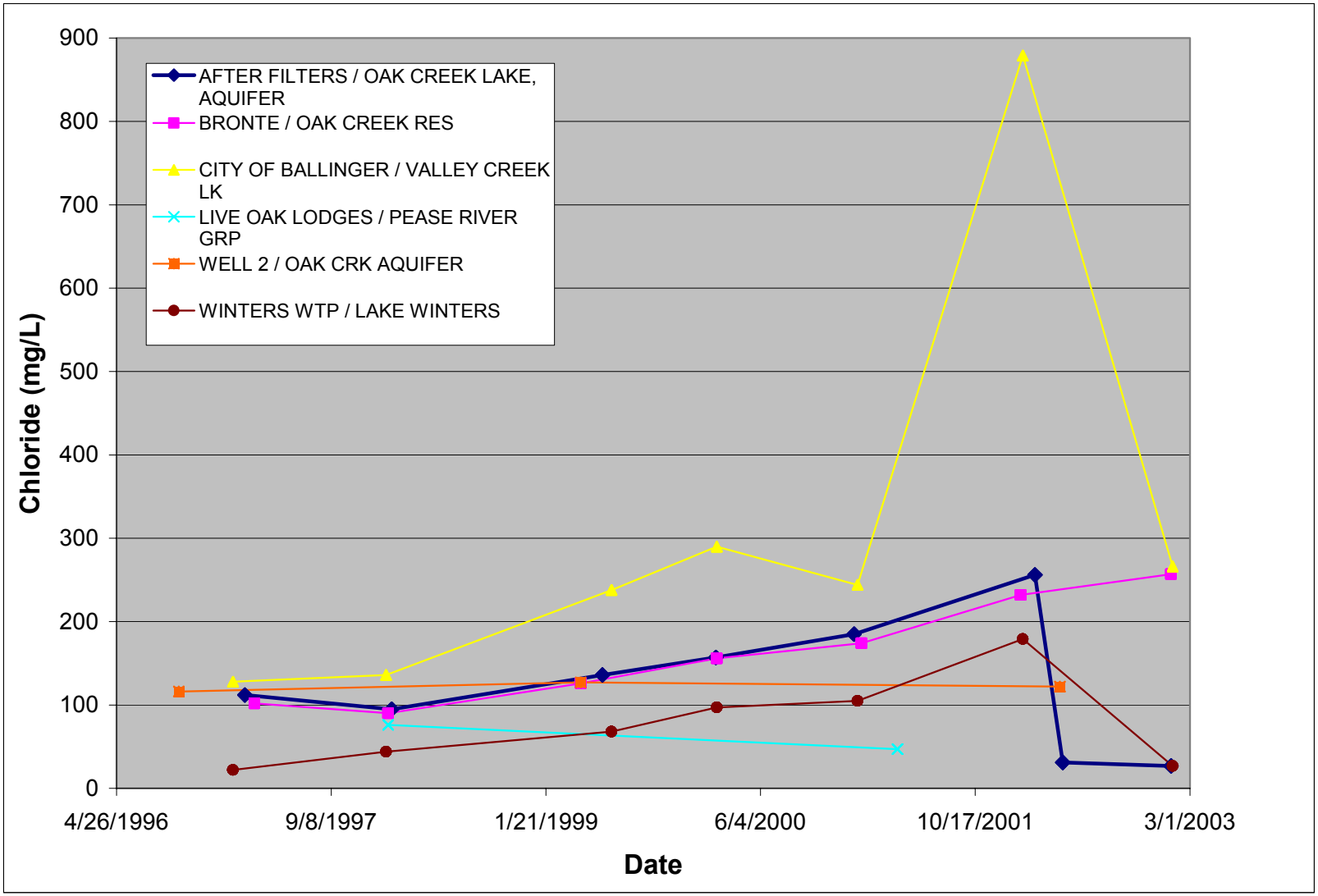
Average Concentration
- **Chloride**
- **Total Dissolved Solids**
- **Sulfate**
- **Streams**

0 9 Miles

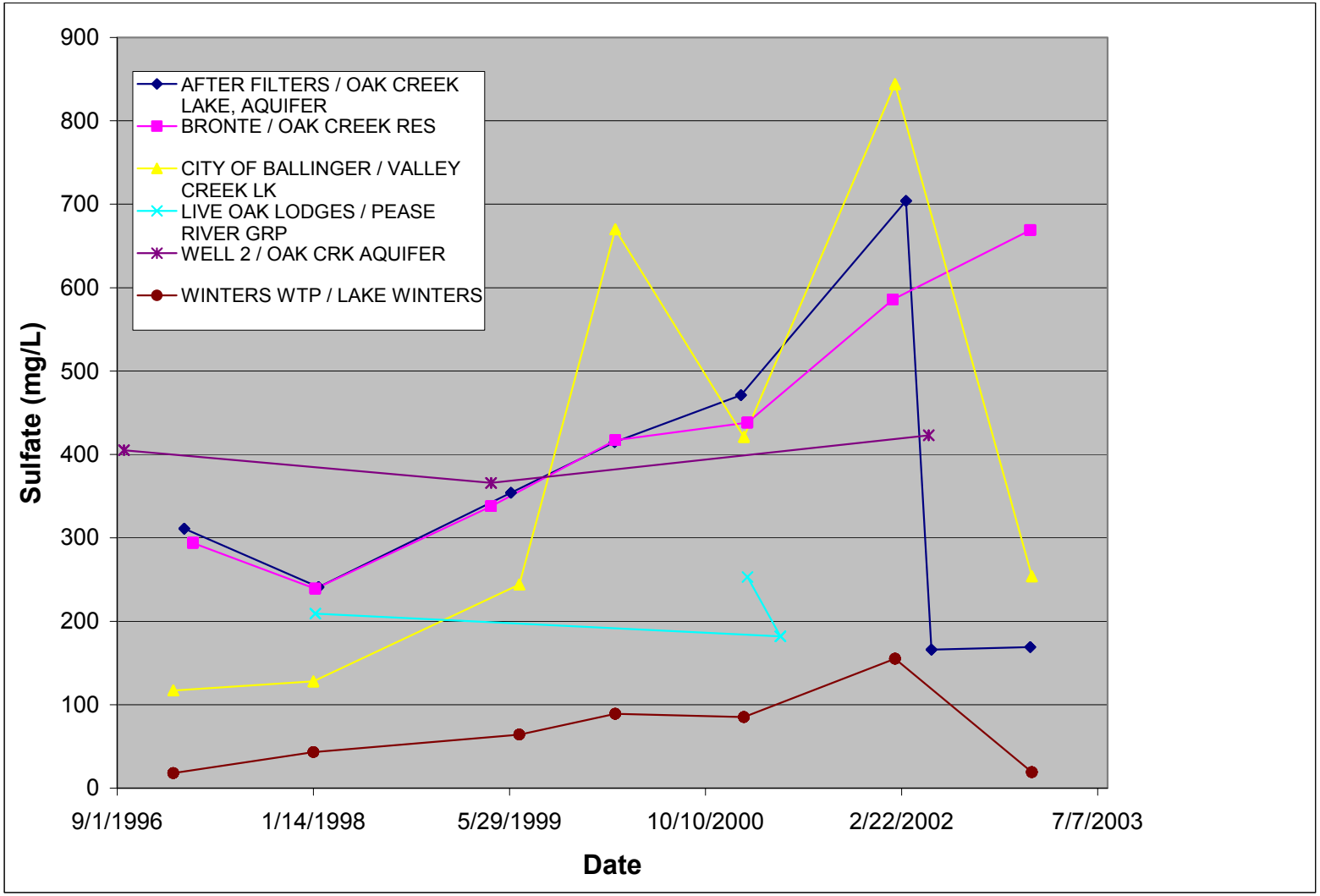
Range of Average Concentrations Among the 6 Wells:

Chloride 64-312 mg/L
Sulfate 68-412 mg/L
Total Dissolved Solids 338-1100 mg/L

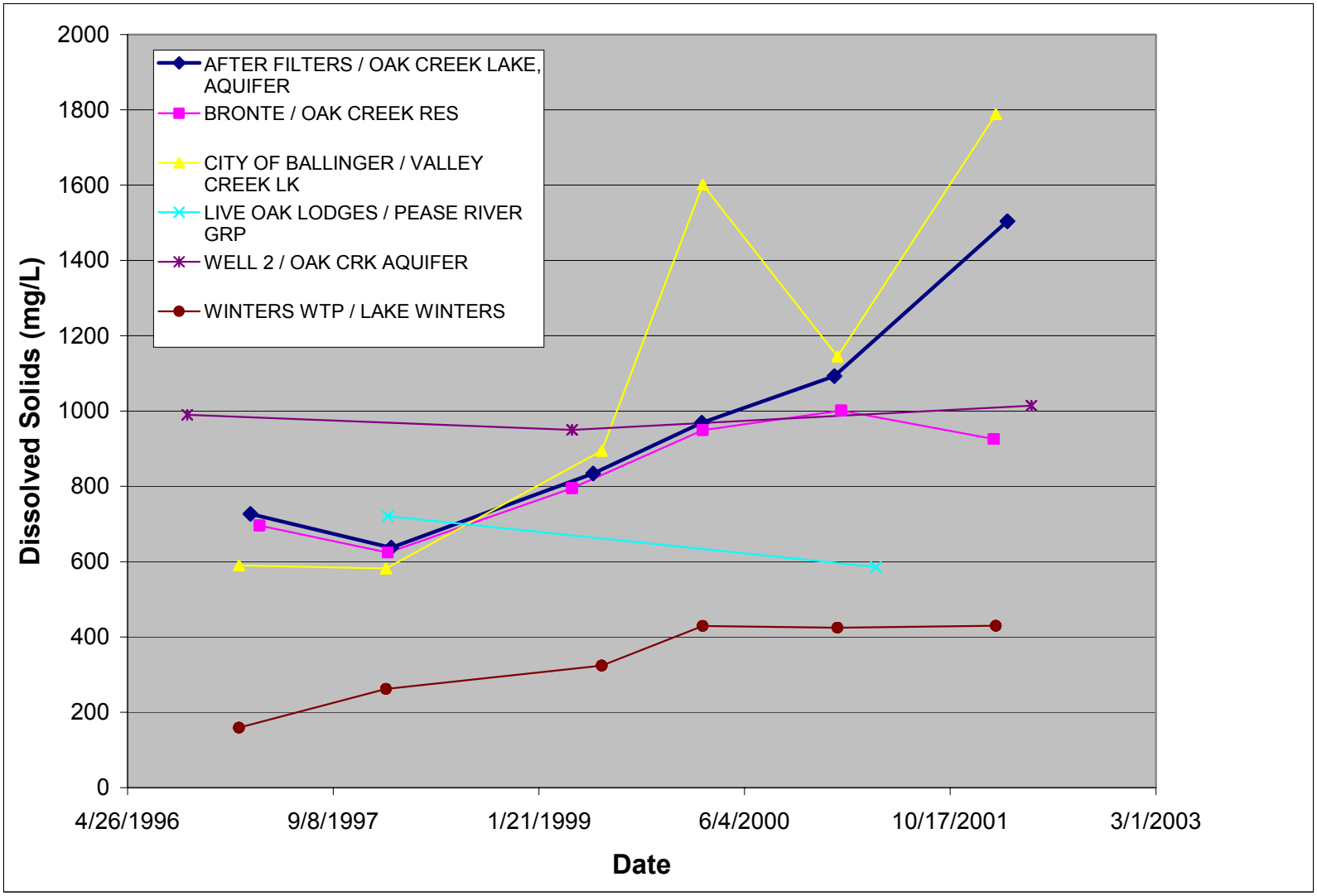
Groundwater Chloride Concentrations



Groundwater Sulfide Concentrations



Groundwater TDS Concentrations



Human Sources

- Oil-Related Sources
  - Determined from groundwater water quality data
  - Surface water quality data
  - Estimates of natural salinity sources
  - Locations of known oil field operations, wells, and brine pits in the watershed
- Permitted Facilities
  - Computed based on average discharge flow and pollutant concentration

Issues

- Complex System.
- It is not possible to discriminate between the various sources of salinity in the Shallow or the deep subsurface.
- Headwater condition

Bureau of Economic Geology

- A study has been proposed by the Bureau of Economic Geology (BEG) to better assess the salinity sources contributing to the impairment of the Colorado River. The data collected through this study will be used to define pollutant loading rates for the water quality model. In addition, collected data will prove useful in the implementation of required pollutant source reductions determined from the TMDL process.

Proposed Study

- **Phase I:**
- Delineation of the spatial extent of non-point salinity sources that may contribute to the impairment of the Colorado River.
- Ground-based geophysical surveys using electromagnetic (EM) induction methods will be employed to map salinity sources in the watershed.
- The utility of an airborne EM survey will be assessed.

- **Phase II:**
- Characterization of salinity sources. Geochemical analyses will be employed to determine source type for both surface and groundwater samples. In particular, these analyses will estimate the percentage of anthropogenic vs. natural sources in analyzed water samples.

BEG Study

- The results from the BEG source assessment study will be directly incorporated in the development of the HSPF model. GIS analyses will be performed to assign pollutant loadings from identified non-point sources as follows:

BEG Study: Natural Sources

Natural Sources

- Salinity will be determined based on a combination of
  - Geochemical information
  - Geophysical survey.
  - GIS overlay analyses will be employed using results from the BEG source assessment survey and underlying aquifer information.
  - The primary direction of aquifer groundwater flow will be used to link sources to observed instream loads. G
  - Geochemical information derived from stream samples and well samples will be used to estimate the percentage of observed stream load resulting from natural geologic formations.

- Sources of salinity from phreatophytic brush such as salt cedar will be defined within a specified stream buffer based on geophysical survey results for near surface sources of salinity.

BEG Study: Anthropogenic Sources

Anthropogenic Sources

- Salinity derived from anthropogenic sources including leaking oil wells, brine pits, and brine injection will be determined based on a combination of
- Geochemical information
- Geophysical survey.
- GIS overlay analyses will be employed using results from the BEG source assessment survey and underlying aquifer information. The primary direction of aquifer groundwater flow will be used to link sources to observed instream loads.
- Geochemical information derived from stream samples and well samples will be used to estimate the percentage of observed stream load resulting from anthropogenic sources.

BEG Study

- Integrated into the TMDL development to minimize replication of efforts and to conserve resources.
- Duration: 3 – 6 Months

Next Steps

- Continue data collection
- Analyze data to investigate sources of salinity in the watershed
- Finalize watershed model input parameters
- Calculate the salinity loading from the identified sources in the watershed
- Develop the TMDL allocation Scenarios
- Prepare the Draft TMDL
- Prepare for Public Meeting

Local TMDL Contacts

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